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The embryology of Rhytidophyllum

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(WITH PLATE 10)

The family *Gesneriaceae* is tropical and sub-tropical in its distribution, but is closely related to certain other families which are much more widely distributed. The writer accepted an opportunity to make a study of the genus *Rhytidophyllum*, which may be considered characteristic of the family, hoping at some future time to be able to make a comparative study of some of the more northern species of the related families. The first studies were made from *R. crenulatum* DC. and most of the figures were drawn from that material. Later, upon securing material of *R. tomentosum* Mart., a comparative study was made. These two species show very distinct external specific differences, but the morphology of the embryo-sac and embryo is practically the same, the ovules and internal structures of *R. tomentosum* being slightly smaller than in *R. crenulatum*. On account of various chemical substances of these plants, which are not thoroughly understood, the technique was rather difficult and the chromic acid mixtures proved absolutely useless. The following mixtures were used with success:

(*a*)	Saturated aqueous solution picric acid	100 c.c.
	Glacial acetic acid	1 c.c.
(*b*)	Saturated 70 per cent. alc. sol. picric acid	100 c.c.
	Glacial acetic acid	1 c.c.
(*c*)	Saturated aqueous solution picric acid	100 c.c.
	Sulphuric acid	2 c.c.
(*d*)	Saturated 70 per cent. alc. sol. picric acid	100 c.c.
	Sulphuric acid	2 c.c.

The first solution was by far the most successful. The material was then treated in the usual manner, imbedded in paraffine, sectioned and stained.

The ovules assume the anatropous form (*figures 1, 2*) very early. The archesporium originates as a single sub-epidermal cell (*figures 1a, 2*). In one instance only, of a large number examined, was this cell divided into megaspores and then only two cells were formed (*figure 3*). The single archesporial cell elongates without division, in the antipolar direction, the new part being smaller in diameter than the older part (*figures 1b, 4*). This cell then elongates very rapidly, and forms the two- and four-nucleate stages of the embryo-sac (*figures 1c, 5, 6*). At this time the sac is usually about twice as long as wide. Without further enlargement of the sac the nuclei now divide, thus forming the eight-nucleate stage. The egg is large and the synergids very small (*figure 7*), but they stain very deeply. The antipodals (*figures 8, 9*) are about the same size as the synergids and disintegrate very quickly. The polar nuclei (*figure 10*) may unite in any part of the sac, but usually in the antipodal end. The micropyle and the pollen-tube are very conspicuous at this time, and the entrance of the latter obliterates the synergids (*figures 11, 12*). Immediately after the completion of the eight-nucleate stage of the sac the antipodals disintegrate and a very long tube is formed extending to the opposite end of the ovule (*figures 1d, 7, 8, 9, 12*). The formation of this tube is the result of the disintegration of a single row of cells. In a very short time the nucellar cells which surround this tube disintegrate, producing a sac uniform in diameter, extending almost the entire length of the ovule and enclosed by only a few layers of nucellar cells, usually not more than six. This is followed by fertilization of the egg and union of the polar nuclei. The endosperm undergoes its primary division (*figures 12, 13*) before the division of the egg. One of the daughter-nuclei remains in the micropylar part of the sac, while the other enters the tube and the two are separated by a wall (*figure 13*) which persists for a very short time. Similar walls, dividing the two daughter-nuclei of the primary division of the endosperm-nuclei have been described in a number of plants by Hofmeister (4), Johnson (5, 6), Schaffner (10), Cook (1), Strasburger (11), and others. Both nuclei now undergo repeated divisions, forming a cellular endosperm. The endosperm in the micropylar part of the sac disintegrates very quickly, but the other persists for some time (*figures 14, 15*). It is very evident that the disintegration of the endosperm begins at the micropylar end of the sac and progresses rapidly towards the opposite end. In this end of the sac there was always present a single large pyriform cell (*figure 15*) whose origin was difficult to determine, but it appeared to be the result of one of the early divisions of the endosperm.

At the time of the primary division of the endosperm-nucleus some starch was present in the sac and also in the cells immediately surrounding the micropyle, and in a very short time all the cells lining the sac developed starch. Before the disintegration of the endosperm was complete these nucellar cells were also undergoing disintegration and this continued until the entire nucellus had disappeared. In brief, both the endosperm and the nucellus undergo disintegration to feed a rapidly growing embryo and eventually leave the embryo surrounded by the integuments only.

When the embryo-sac is in the eight-nucleate stage (*figure 1d*) the nucellus consists of four to six layers of cells; as the ovule increases in size the cells divide, but the inner cells are continually disintegrating to feed the embryo. At about the time of the appearance of the cotyledons (*figure 23a*) the nucellus consists of four or five layers of cells (*figure 16*), of which the inner cells show the effects of disintegration. After this time no nucellar cells are formed, but those already existing are gradually used by the growing embryo (*figure 25*).

The embryo. — The fertilized egg, by successive divisions, forms an embryo of from four to six cells in linear arrangement (*figures 17, 18*), with the basal cell very much elongated, but not enlarged as in the case of *Capsella Bursa-pastoris* as described by Coulter and Chamberlain (2) and Hanstein (3). The apical cell now divides by two longitudinal walls placed at right angles to each other, thus forming the quadrant stage (*figure 17*). The quadrant is now divided by a cross-wall, thus forming the octant stage. Instead of producing the dermatogen immediately, as in the case of *Capsella Bursa-pastoris* and *Alyssum macrocarpum*, it now divides repeatedly by longitudinal walls (*figure 18*). At the same time the suspensor becomes very large and elongates, pushing itself back into the micropyle and forming an enlargement (*figure 18*). It apparently functions for a short time as a simple haustorium, but very soon disintegrates. However, its old course can still be traced (*figure 19*) in very late stages. In the meantime, the small suspensor cells next to the embryo divide by cross-walls. The embryo now increases in size and the differentiation into dermatogen, periblem and plerome occurs very early (*figures 20–23*). The cell *a* nearest the embryo (*figure 18*), to which we will hereafter refer as the basal cell, now divides by a cross-wall into two cells, *b* and *b'* (*figure 20*). Cell *b'* now divides by longitudinal division into four cells, which form the root-tip (*figures 21, 22, 23a, 23b*). Cell *b* now divides by both transverse and longitudinal divisions (*figures 22, 23*) into four cells of which the upper layer *b''* (*figures 23a, 23b*) forms the dermatogen of the root-tip.

At about the time of the formation of the dermatogen of the root-tip the two cotyledons appear (*figure 23 a*), one of which is usually slightly larger than the other. Examination of a large number of embryos slightly older than *figure 23* indicated that these cotyledons have an independent origin. The endosperm has entirely disappeared by this time and the nucellus is very much reduced (*figure 16*). The embryo now enlarges rapidly, gradually utilizing the last of the nucellar tissue, and when fully mature is surrounded only by the integuments.

Abnormal embryos. — Four abnormal embryos were observed. Two of these embryos (*figure 24*) were about the same age as those in *figure 23* but had elongated without producing cotyledons and without differentiation of tissues into plerome and periblem. The other two abnormal embryos each had three equally well developed cotyledons. They were the same age as in *figure 25*, and were cut in cross sections.

SUMMARY

1. The archesporium is a single sub-epidermal cell.

2. This usually becomes the functional megaspore without previous subdivisions.

3. There is nothing unusual in the formation of the embryo-sac.

4. The formation of the embryo is typical of the dicotyledons as illustrated by *Capsella Bursa-pastoris*, except for variations in the formation of the dermatogen and in the basal (hypophysis) region.

5. The endosperm is of the cellular type and is formed in the usual manner but disintegrates very early.

6. Both endosperm and nucellus are utilized to feed the growing embryo, eventually leaving the embryo surrounded only by the integuments.

I wish at this time to express my thanks to Professor C. F. Baker of the Estacion Central Agronomica, Santiago de las Vegas, Cuba, for assistance in securing the material; to the workers of the New York Botanical Garden for its determination; and to Professor F. E. Lloyd of the Desert Botanical Laboratory, Tucson, Arizona, for reviewing the manuscript and for valuable suggestions.

The *Rhytidophyllum crenulatum* DC. was collected on the walls of Fort Cabañas, Havana, Cuba, and the *R. tomentosum* Mart. was collected on the hills near the village of Managua in the Province of Havana, Cuba. Specimens of both collections are deposited in the herbarium of the New York Botanical Garden.

ESTACION CENTRAL AGRONOMICA,
SANTIAGO DE LAS VEGAS, CUBA.

LITERATURE

1. **Cook, M. T.** Development of the embryo-sac and embryo of *Castalia odorata* and *Nymphaea advena*. Bull. Torrey Club **29** : 211–220. *pl. 12, 13.* 1902.
2. **Coulter, J. M. & Chamberlain, C. J.** Morphology of the angiosperms. (Part II. Spermatophytes.) 1903.
3. **Hanstein, J.** Die Entwicklung des Keimes der Monokotylen und Dikotylen. Bot. Abhandl. $\mathbf{1}^1$: 1–112. *pl. 1–18.* 1870.
4. **Hofmeister, W.** Neuere Beobachtungen über Embryobildung der Phanerogamen. Jahrb. Wiss. Bot. **1** : 82–188. *pl. 7–10.* 1858.
5. **Johnson, D. S.** On the development of the *Saururus cernuus* L. Bull. Torrey Club **27** : 365–372. *pl. 23.* 1900.
6. ————. Seed development in the *Piperaceae* and its bearing on the order. Johns Hopkins Univ. Circ. 178 : 28–31. 1905.
7. **Lewis, C. E.** Studies on some anomalous dicotyledonous plants. Bot. Gaz. **37** : 127–138. *pl. 7, 8.* 1904.
8. **Mottier, D. M.** The embryology of some anomalous dicotyledons. Ann. Bot. **19** : 447–463. *pl. 26, 27.* 1905.
9. **Riddle, L. C.** The embryology of *Alyssum*. Bot. Gaz. **26** : 314–324. *pl. 26–28.* 1898.
10. **Schaffner, J. H.** Contribution to the life history of *Sagittaria variabilis*. Bot. Gaz. **23** : 252–273. *pl. 20–26.* 1897.
11. **Strasburger, E.** Ein Beitrag zur Kenntniss von *Ceratophyllum submersum* und phylogenetische Eröterungen. Jahrb. Wiss. Bot. **37** : 477–526. *pl. 9–11.* 1902.

Explanation of plate 10

Figures 1, 19 and 25 were drawn with Zeiss No. 2 ocular and No. C objective and are slightly diagrammatic. All other figures were drawn with Zeiss No. 2 ocular and 1/12 oil-immersion objective.

All figures drawn from *Rhytidophyllum crenulatum*, except figures 2 and 25, which were drawn from *R. tomentosum*.

FIG. 1*a*. Ovule with archesporial cell.

FIG. 1*b*. Ovule with functional megaspore.

FIG. 1*c*. Ovule with sac in four-nucleate stage.

FIG. 1*d*. Ovule with sac in eight-nucleate stage.

FIG. 2. Same as Fig. 1*a*.

FIG. 3. Two megaspores.

FIG. 4. Same as Fig. 1*b*.

FIG. 5. Two-nucleate stage of embryo-sac.

FIG. 6. Four-nucleate stage of embryo-sac. Same as Fig. 1*c*.

FIG. 7. Eight-nucleate stage of embryo-sac showing egg-apparatus and one polar nucleus.

FIG. 8 and 9. The antipodal nuclei.

FIG. 10. The union of the polar nuclei.

FIG. 11. Embryo-sac showing egg, pollen-tube and endosperm nucleus.

FIG. 12. Embryo-sac showing fertilized egg, pollen-tube and two daughter-nuclei formed by the first division of the endosperm-cell.

FIG. 13. Daughter-nuclei formed by the first division of the endosperm-nucleus and separated by a wall.

FIG. 14. Endosperm in the antipodal end of the sac.

FIG. 15. Much older and showing the large pyriform cell.

FIG. 16. Nucellus and integuments. Slightly older than Fig. 23.

FIG. 17. Young embryo showing early divisions.

FIG. 18. Young embryo showing later divisions and haustorial development of the suspensor.

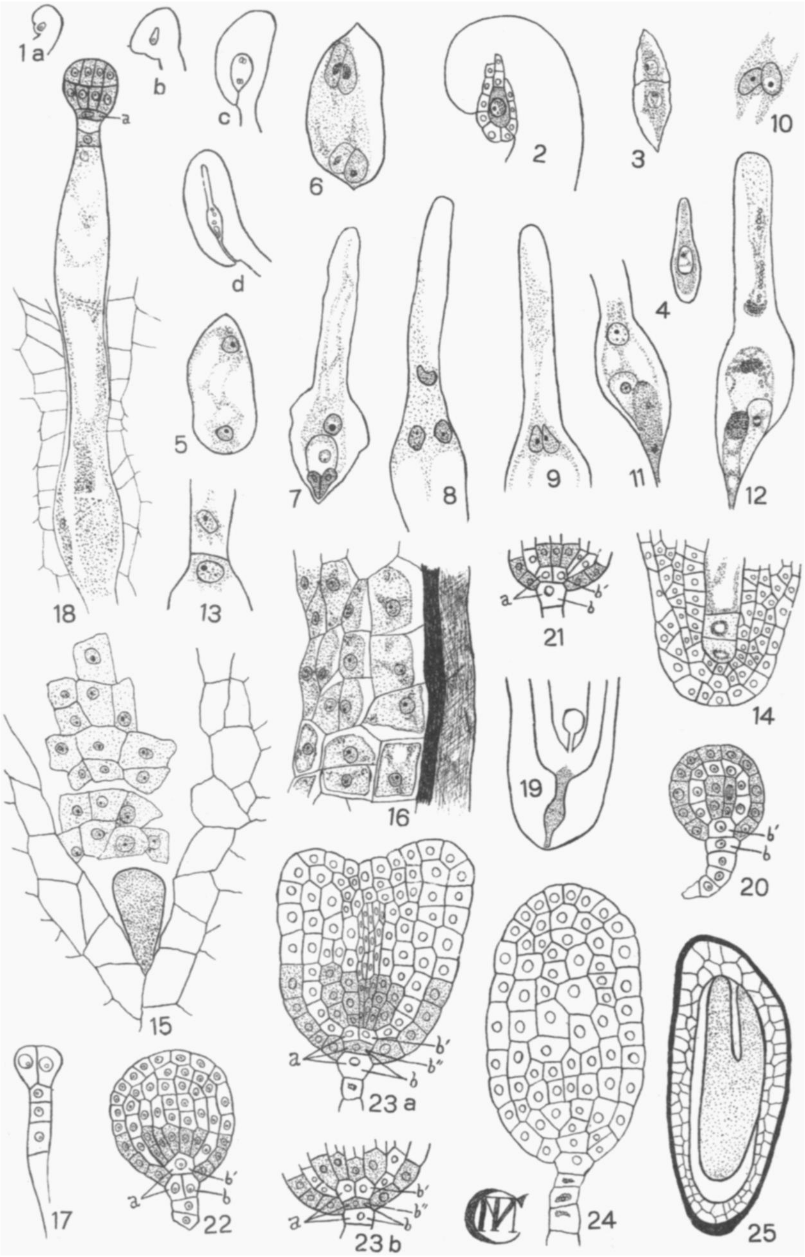
FIG. 19. Remains of haustorial suspensor. Same age as Fig. 20.

FIG. 20–22. Spherical embryo showing dermatogen, plerome, periblem, and basal cells.

FIG. 23, *a* and *b*. Embryos showing origin of cotyledons and the basal cells.

FIG. 24. Abnormal embryo.

FIG. 25. Embryo, two layers of nucellar cells and integuments.



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